TV RECEPTION FROM SATELLITES

PROJECT REPORT

Department of Electronics & Telecommunication Engineering
University of Moratuwa
SRI LANKA

TV RECEPTION FROM SATELLITES

PROJECT REPORT

SUBMITTED IN PARTIAL FULFILMENT OF THE DEGREE OF BACHELOR OF SCIENCE (ENGINEERING)

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F O R E W A R D.

The B. Sc. Engineering degree course consists of four years of studies at the university and six months of in-plant training.

In order to complete the degree the undergraduates are expected to do a project during their final year of studies.

For this purpose, our group consisting of four, has chosen "TV RECEPTION FROM SATELLITES" as the project.

This report contains a description of our project and the work performed during May 1984 and January 1985.

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A C K N O W L E D G E M E N T .

We wish to express our appreciation and thanks to Dr. (Mrs) I. J. Dayawansa for the help, encouragement and ideas given, which we found invaluable in completing our project successfully.

The ideas, assistance and the backing given to us by our supervisors Messrs. S. Athukorale and J. K. Samarabandu are much appreciated.

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A Geostationary Satellite Look Angles

B Software Program for the Antenna Directing System.

C Computer Ports and Circuit Components.

REFERENCES.

SUMMARY.

The following were the basic aims of our project, "TV RECEPTION FROM SATELLITES", in short.

(I) To study the TVRO system and to set it up so that it is usable without any danger, difficulty and ambiguity etc.

(2) To receive TV programmes from many satellites as possible.

(3) To observe and study their reception conditions and to make possible improvements.

(4) To design and implement a low cost, home applicable, automatic antenna directing system with the aid of a micro computer.

We have been able to success fully achieve these objectives except (2) above. The causes for this is explained in chapter III.

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION.

The project "TV RECEPTION FROM SATELLITES" is closely related to the field of telecommunications.

Television is the most informative mass communication media of the present times. Although TV is the youngest of the mass communication systems, it is used almost in every country in the world.

Since it gives a large amount of information it obviously needs a bigger bandwidth than any other communication system. More over, TV signals must be broadcast so that people could receive them. This gave the telecommunication engineers a challenge. There are many ways in which this challenge could be met depending on the circumstances.

Basically there were two problems that had to be solved. They are, how signals could be sent to people living close by and to people residing far away.

The solution to the first situation is twofold.

(I) Use of cable network.

This would look just like a telephone network; each TV user having a cable for his use. The video baseband signals are sent through cables without modulation process.

This system is better in cases where there are a few users in the same locality than in a large community.

(2) Use of radio waves.

This method is widely used and gives a lot of users easy accessibility to TV signals. However as the bandwidth of the TV signals is quite high it is necessary to use a carrier atleast in the VHF range. The use of carriers beyond the UHF range is not possible as they have highly directional properties.

VHF and UHF signals also show line of sight properties and hence will be accessible only in a limited area around the transmitting station. This indicates that inorder to transmit TV signals to a large area we should have several transmitting antennae.

The solution to the second situation can be found in many ways.

(I) Use of a long distant cable to transmit TV signals to a broadcasting station located at the far end.

(2) Use of microwave repeaters.

(3) Use of satellite repeaters.

(4) Use of optical fibre repeaters.

The first two solutions listed above are conventional ones while the latter two are modern.

However the use of optical fibre repeaters are still in the research stage and will be available commercially in the near future.

Geosynchronous Satellites Around the World
BAND C K BOTH
EXISTING
PROPOSED
AUSSAT I (1985) AUSTRALIA 156° E
AUSSAT II (1986) AUSTRALIA 160° E
AUSSAT III (1987) AUSTRALIA 164° E
INTELSAT IVA F6 175° E
INTELSAT IVA F3 179° E
143° W SATCOM V US
141° W UNASSIGNED
139° W SATCOM IR US
137° W UNASSIGNED
134° W GALAXY I (1983) US
132° W RAINBOW I (1986) US
131° W SATCOM IIIR US
130° W ABCI (1986) US
128° W ASC I (1985) US
127° W COMSTAR IV US
126° W RCA (1985) US
125° W TELSTAR 3C (1984) US
124° W SBS V (1986) US
123° W WESTAR V US
122° W SPACENET I (1984) US
120° W USAT I (1984) US
119° W SATCOM II US
117.5° W ANIK C3 CANADA
116.5° W MORELLOS I (1985) MEXICO
113.5° W MORELLOS II (1985) MEXICO
112.5° W ANIK C2 CANADA
109° W ANIK B1, ANIK D2 (1984) CANADA
108.5° W ANIK C1 (1984) CANADA
105° W G-STAR US
104.5° W ANIK D1 CANADA
103° W G-STAR US
101° W UNASSIGNED
99° W SBS I, WESTAR IV US
97° W SBS II US
96° W TELSTAR 3A (1983) US
95° W SBS III, COMSTAR II US
93.5° W GALAXY III (1984) US
93° W UNASSIGNED
76° W TELSTAR (1985) US
75° W UNASSIGNED
74° W GALAXY II (1983) US
73° W UNASSIGNED
72° W SATCOM VI (1986) US
71° W UNASSIGNED US
69° W SPACENET II US
67° W SATCOM VI (1986) US
53° W INTELSAT IV F1
UNISAT I (1986) UK
INTELSAT IVA F1 31° W
INTELSAT V F2 34.5° W
77° W RCA (1987) US
78.5° W WESTAR VI (1983) US
79° W RAINBOW II (1986) WESTAR II US
81° W ASC II (1986) US
83° W ABCI (1987) SATCOM IV US
85° W USAT (1987) US
87° W RCA (1986) COMSTAR III US
88.5° W TELSTAR 3B (1984) US
89° W SBS IV (1984) US
135° E SAKURA A2 (1983) JAPAN
130° E SAKURA B2 (1983) JAPAN
PALAPA B3 (1985) INDONESIA 118° E
PALAPA B2 (1984 INDONESIA 113° E
BSE-2, BS-2A (1984) 110° E
BS-2B (1985) JAPAN
PALAPA B1 (1983) INDONESIA 108° E
ISCOM I INDIA 105° E
INSAT 1B (1983) INDIA 94° E
GORIZONT USSR 90° E
RADUGA USSR 86° E
PALAPA A2 INDONESIA 83° E
PALAPA A1 INDONESIA 77° E
INTELSAT V F5 63° E
INTELSAT V F1, INTELSAT V F7 60° E
INTELSAT IVA F2 57° E
GORIZONT USSR 53° E
RADUGA USSR 35° E
ARABSAT (1985) 26° E
ARABSAT (1984) 19° E
OTS-2, ECS-2 (1984) ESA 15° E
ECS-1 (1983) ESA 10° E
TELE-X (1986) SWEDEN 5° E
INTELSAT IV F8 1° W
10° W TELECOM I (1983)
TELECOM II (1983) FRANCO-GERMAN
11.5° W SYMPHONIE, SYMPHONIE II FRANCO-GERMAN
14° W GORIZONT USSR
18.5° W INTELSAT V F6
19° W TV-SAT A3 (1985) GERMANY L-SAT (1987) ESA
LUX-SAT (1987) LUXEMBOURG TDF-1 (1985) FRANCE
21.5° W INTELSAT IVA F4
24.5° W INTELSAT V F3, SIRIO ITALY
27.5° W INTELSAT V F4

I.I. Satellite Communication.

It was not far back in the history that the feasibility of satellite repeaters was disclosed by the eminant science fiction author Dr. Arthur C. Clarke.

In I945, in an article of the "wireless world" he suggested the possibility of world wide coverage of communication signals using geostationary satellites with special emphasis to TV relaying. He said, that the use of a minimum of three geostationary satellites, would give us globle communication.

Satellite communication provides many communication services such as television, telegraph, telex, data, facsimile etc. for local use as well as for international use.

Satellite communication, specially geostationary satellite communication, is much preferred because of many reasons.

(I) Capability of multiple access.
(2) Wide satellite coverage.
(3) High quality and wide band communication.
(4) Availability for mobile communication.
(5) Economic efficiency.
(6) Power requirements of satellite is low and economical.
(7) Communication around the clock.
(8) High reliability.
(9) Cost independent of length.
(IO) Short term project.
(II) Easy tracking of satellites.

At the begining of satellite communication, it was necessary to spend a large amount of money to receive from a satellite. The ground segment equipment alone cost billions of rupees and hence only governments or companies with large amounts of capital could afford to possess such a system and provide satellite communication.

The satellite earth station at Padukka is a ground segment of this kind.

I.2. TVRO

One of the major advantages of a geostationary satellite communication system is it's inherent tracking ease. Due to this character and many other factors such as development of electronics etc., low cost earth stations were possible and the TVRO (television receive only) industry ivolved.

We must not forget the fact that satellites are used for TV relaying and therefore the receive only facility is not a limitation for entertainment purposes. Transmitting facility is required only in the case of two way communication such as telephone, telex etc.

Use of low cost TVRO systems for entertainment and information is wide spread in many countries.

However the TVRO industry does not seem to be popular in this region of countries except in India and a few others, which may be because quite a few satellites look over this area, the cost etc.

FIG (12)

THE PROJECT SET-UP

I.3. TVRO at the University of Moratuwa.

On the 30th of November 1983, with the inaugaration of the Arthur Clarke centre, the University of Moratuwa received a gift of a 20 foot diameter antenna and a TVRO system.

Since there has been no survey of TVRO reception conditions in Sri Lanka, up to date, the main idea behind the installation of the antenna receiving equipment, we feel, is to findout the feasibility of producing reception devices for this part of the world. Also if such a case is feasible how it could be done economically.

We believe that the study conducted by us would help in achieving the above.

I.4. The Project

Our project was mainly concerned with the reception of TV signals from satellites and thus we employed the TVRO system and the 20 foot diameter antenna which is mounted on top of the four storeyed building of the University of Moratuwa.

Stage I

Our basic aim was to receive from many satellites as possible by mechanically manoeurvering the position of the antenna and then to record the position of the antenna at which these satellites could be received.

Next our intention was to find out the reception conditions, the picture quality and the time of day at which the particular satellite would be receivable. These are discussed in detail in chapter III along with the problems encountered in the process.

By considering all these (i.e. the number of satellites receivable, the quality and time of day etc.) we could determine whether any sought of receiving equipment production is feasible. Ofcourse we must also be aware of other factors such as legal, economical etc., affecting the final decision.

Stage II

Directing the antenna to satellites by mechanically manoeuvreing of the antenna position becomes a very tedious exercise. Thus the second part of our project was to simplify the above problem.

In order to achieve this we thought of devicing an automatic control system.

By using this control system we would be able to rotate the antenna and make it point to a particular satellite from which we desire to receive. This way we would be avoiding the difficulty of manually accessing satellites.

Chapter IV would give a detailed explanation of how we achieved the above objective.

CHAPTER II

SYSTEM DESCRIPTION

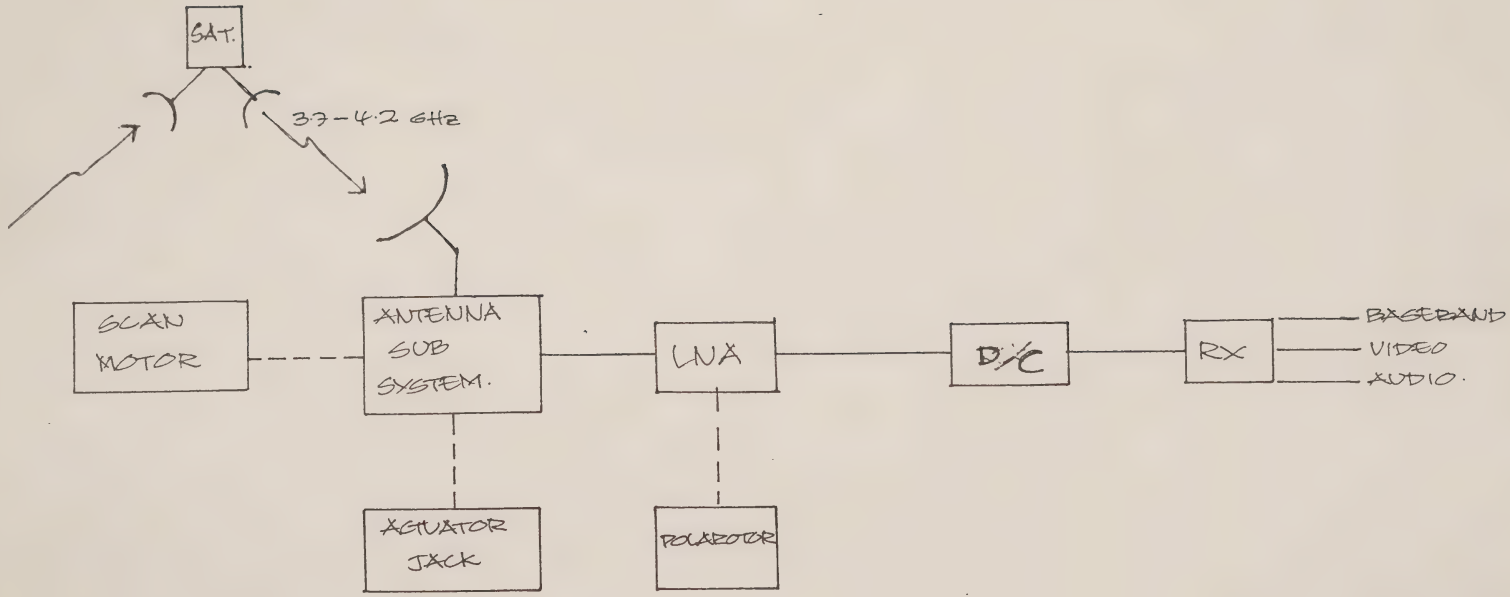


FIG. 2.1 COMMUNICATION CIRCUIT.

CHAPTER II

SYSTEM DESCRIPTION

2.I. Communication Circuit.

The system employed in our project is basically a TVRO system and thus the transmit facilities do not exist.

The communication circuit consists of only the receive path as shown in the fig. (2.I)

The satellite which receives the signals of frequency range 5.925 - 6.425 GHz down converts them by 2.225 GHz before re-radiating them towards the earth. The receive signal therefore would be within the frequency range 3.7 - 4.2 GHz.

The 20 foot diameter parabolic antenna mounted on top of the four storeyed building of the University of Moratuwa receives the parallel beams of 3.7 - 4.2 GHz frequency range radiated from the satellite.

The LNA placed at the focus of this parabolic antenna will receive this signal and amplify it.

The amplified output of the LNA goes to a down converter. The down converter output which lies between 250 - 750 MHz is sent to the receiver where it is converted to a 70 MHz IF frequency.

FIG (2.2)

20 FOOT PARABOLIC ANTENNA

This signal is now demodulated and the baseband is obtained. The receiver has facilities of giving us either the total baseband or the audio and video separately.

The TVRO system used consists of several sub-systems. They are,

(I) Antenna sub-system.

(2) LNA sub-system.

(3) Down converter sub-system.

(4) Receiver sub-system.

(5) Auxilliary Equipment.

a. Horizon to horizon scanning motor.

b. Actuator Jack.

c. Polar-rotor.

d. Limit Switch.

e. Transformer.

2.I.I. Antenna sub-system.

The 20 foot parabolic dish as in fig. (2.2) is of high quality aluminum alloy and has a zinc chromate base. The dish is used to collect the signals sent from the satellite. These signals are received by the LNA which is placed at the focus of the parabola.

The dish itself is inherently rigid and will not deform with age. The antenna is more or less mainten ance free.

The sturdy steel polarmount with a low centre of gravity makes the entire assembly wind resistant.

The specifications and the data of the antenna are as follows.

Antenna	- ADM 20
Manufacturer	- Antenna Development and Manufacturing, Poplar Bluff, MO.
Antenna Type	- Prime focus
Antenna Mount	- Equitorial Polar; Horizon to horizon scan.
Antenna Diameter	- 20.0 feet (6.10 meters) F/D 0.4
Construction	- 24 panel(0.09 thickness) high quality 5052 - H32 Al alloy.
Feed	- Single linear or dual orthogonal linear polarization, Rotatable 360°
Frequency	- 3.7 - 4.2 GHz.
Gain	- 46.3 dBi at 4.0 GHz
Efficiency	- 66%
Beam Width	- 0.3 dB = 0.85°
	1.0 dB 0.10 dB = 1.20°
Polarmount	
Elevation	- 6.66°
Weight	- Approx. 1840 lbs.

The antenna is protected from lightning by a lightning arrestor.

2.I.2. LNA sub-system

The low noise amplifier (LNA) sub-system is fixed at the focus of the parabolic antenna as shown in fig. (2.3) which is the begining of our receive system. This is done in order to reduce the thermal noise effects that would get added along the cable and mask our signal.However, the position of the LNA causes maintenance difficulties.

As we use a TVRO system which makes us conscious of the cost, we can"t employ extremely high quality LNA's such as the cooled parametric amplifier etc.

The LNA used in our system is a fully solid state FET amplifier which has a gain of approximately 50 dB.

Although the FET does not have a flat gain over the full band width,it is tolerable in our case.

The FET is biased from 23V d.c. which is derived from the satellite receiver. There is only a single cable that provides 23V d.c. to the LNA and brings the received signals to the down converter.

The low noise amplifier will amplify the total bandwidth and will feed it's amplified output to the down converter.

2.I.3. Down-converter sub-system

The amplified signal from the LNA feeds the down converter,and is positioned close to the antenna.

This down conversion is required to make the detection superior and efficient.

In this particular system we used, the down conversion is done in two stages. The first stage is employed to convert the received RF signal to a signal within the range of 250 - 750 MHz.

The second stage is used at the receiver which will make the tuned frequency to be converted to 70 MHz. This is the IF at microwave frequencies.

The down converter used is a fully solid state device and is biased at 23 V d.c. which again is derived from the receiver.

The input and the output of the down-converter are both coaxial cables.

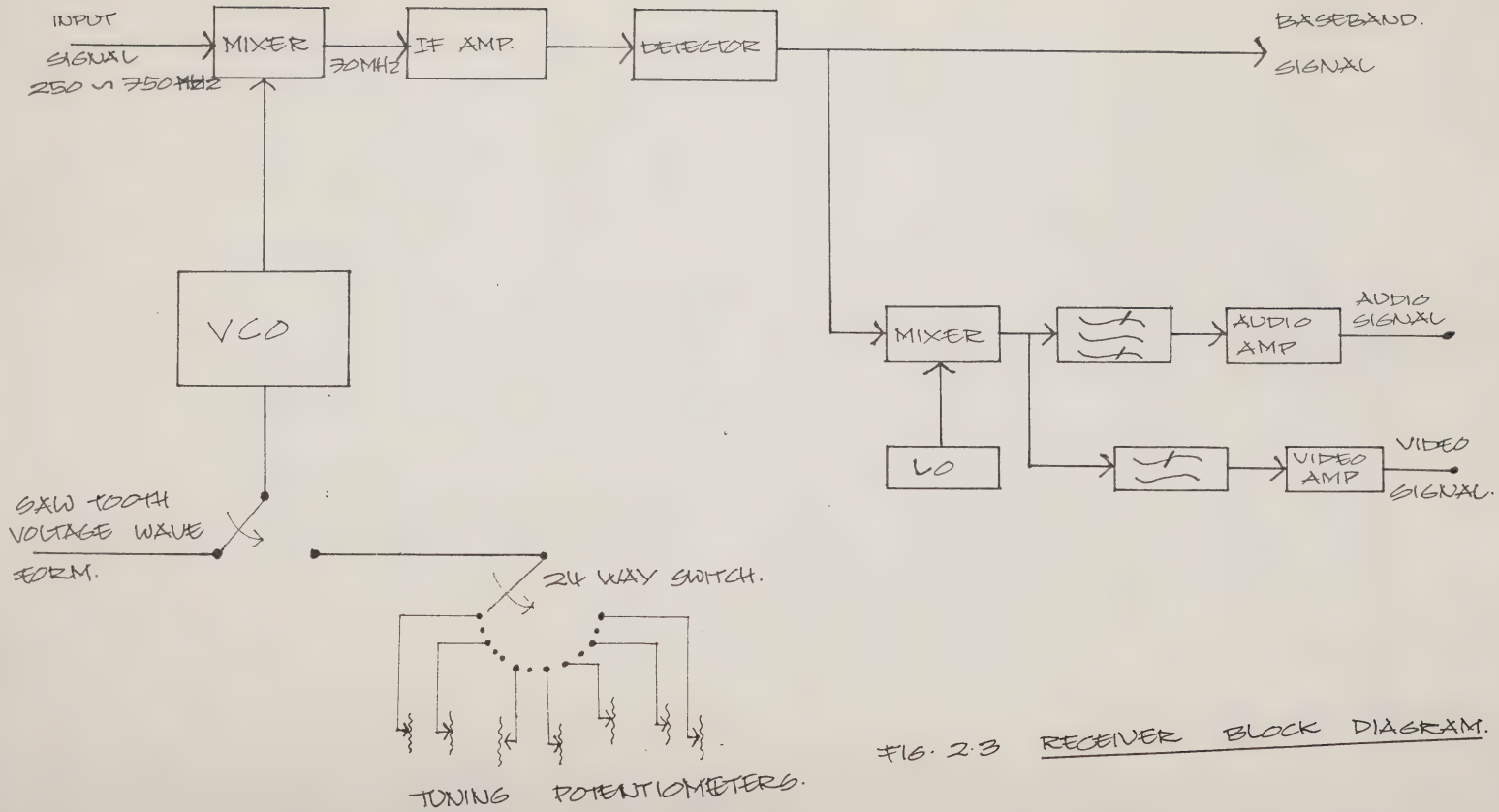


FIG. 2.3 RECEIVER BLOCK DIAGRAM.

2.I.4. Receiver sub-system.

The receiver employed is COM 66T satellite video receiver and is designed to operate from a I20 V, 60 Hz power supply.

The block diagram of the receiver is as shown in fig. (2.4).

IF stage

The input signal to the receiver is in the frequency range of 250 - 750 MHz. This signal is directed to a mixer where it is combined with a tone from a local oscillator to produce a signal of 70 MHz. Our local oscillator frequency is chosen such that the desired IF frequency comes down to 70 MHz.

The local oscillator in the receiver is a variable control oscillator and the frequency of this is varied by varying the voltage supplied to the VCO. The VCO can be switched to two modes of tuning: scanned and fixed.

In scanned tunning the voltage supplied to the VCO is a saw tooth wave allowing the VCO to generate a range of frequencies so that the mixer produces IF for the full range 250-750 MHz, within a short period.

This provision is invaluable in the initial process of acquisition of satellites as we may not know in which transponder the signal is comming.

The second mode of tuning, i.e. fixed, is used under normal viewing conditions when initial acquisition is done so that we know to which transponder we should tune to and hence the local oscillator frequency required.

There is a 24 position switch in the receiver which provides different voltages to the VCO via a miniature multi turn potentio meter. The potentio meters are pre set to give a voltage corresponding to VCO such that it produces the mid frequency plus 7o MHz of each of the 24 transponders.

These tuning and mixing procedures cause any desired signals to be situated around 70 MHz. It is generally accepted that 70 MHz is the IF at microwave frequencies.

The IF signals are then amplified to get the desired signal level at the detected input.

Detector.

The FM detector detects the signals and gives out the baseband. There after this baseband can be further divided into two parts. If we want the audio and the video separately, then the baseband is mixed with a tone so that the audio subcarrier will be moved further up in the frequency scale. This allows us to use filters to separate video and audio subcarriers. The filtered audio subcarrier is demodulated back again to get the audio out.

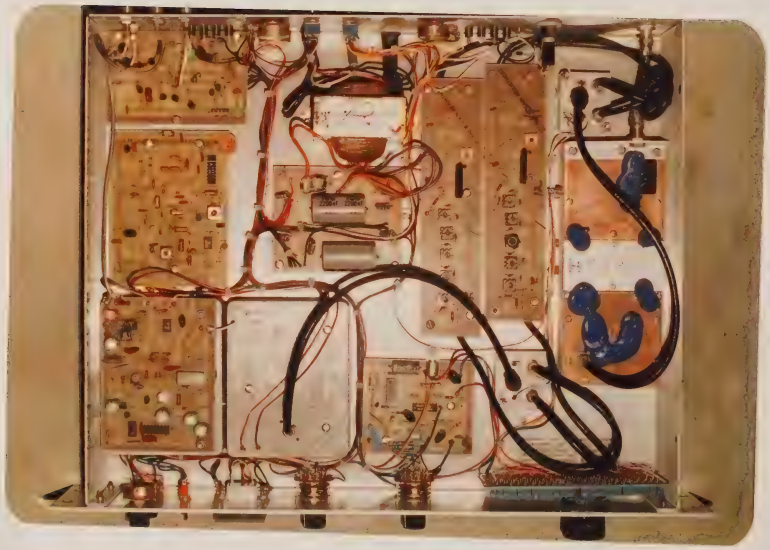


FIG (24)

TOP - REAR VIEW OF RECEIVER

CENTRE - FRONT VIEW OF RECEIVER

BOTTOM - INTERIOR OF RECEIVER

Facilities of the receiver.

The receiver is provided with three meter functions. They are, 'VCO', 'SIGNAL' , and 'DISCRIMINATOR'.

When the switch is set to 'VCO', the meter presents a voltage related to the frequency the receiver is tuned to. The 'SIGNAL' function is used to monitor signal strength for antenna peaking. The switch at the 'DISCRIMINATOR' position is used to monitor the discriminator output. (A reading of IO in the scale is normal).

In order to provide continous tuning of the receiver, a 'SCAN TUNE' feature is also incorporated. This is used to acquire the signal initially. When it is found, the 'scan tune' should be switched off and the receiver tuned to the signal. The meter will show the approximate tuning setting during the scan with the meter function switched to ' VCO'.

The receiver is tuned by the 24 position switch on the front panel. Each switch position has a miniature IO turn potentiometer that is adjusted to select the corresponding transponder channel.

The receiver is also equipped with a tunable audio demodulator capable of receiving subcarriers over the frequency range 4.5-8.2 MHz. The front panel controls on the receiver allows the subcarrier tuning and audio level adjustment.

An additional feature of the tunable audio system is the capability of selecting wide or narrow audio IF bandwidth filters.

The normal audio subcarriers are received in the 'Wide' position of the "wide/narrow audio IF bandwidth" switch, while the 'narrow' position is used to receive special narrow band sub carriers. The RCA jack on the rear pannel allows 1V peak to peak audio.

The video amplifier board contains a video polarity reversing switch which is located on the second die cast enclosure from left corner of the receiver. With the switch flapped to the left, normal transmissions are received.

A video level control (a vertical potentiometer located on the rear edge of this board) is set to provide IV peak video from rear panel video output jack.

Another potentiometer (located near the centre of the video board adjusts the discriminator meter to read IO when the receiver is tuned for equal black and white sparklies.

Both these are previously set (at the factory) and should not be tampered with.

The IF amplifier gain is controlled by a potentiometer on the IF amplifier module located in the centre of the receiver. Normally this adjustment should remain at mid range when the coax lengths connecting the LNA and the receiver are as specified.*

To increase the IF gain the IF gain control has to be tuned counter-clock-wise. The least gain necessary is used while minimizing sparklies.

Precautions

The following are some of the points that should be considered when the receiver is to be used.

(I) Since the line voltage is present in the receiver chasis, the line chord must be disconnected when the receiver interior is exposed as a safety precaution.

(2) To reduce the possibility of electric shock, the receiver and all other system components should be connected to a good ground, This is very important inorder to reduce the risk of the antenna etc. becoming eletrically hot due to floating grounds, electrical shorts etc.

(3) A maximum length of I20 feet (typically 80 feet) of RG-2I7 coax or a length of other coax with a similar amount of attenuation should be used to connect the LNA to the type N fitting on the rear of the receiver.

* Ref. precautions (3) above.

FIG. (2.5)

SCANNING MOTOR

2.I.5. Auxiliary Equipment.

The equipment listed as auxiliary equipment are those that are necessary to use the system effectively and efficiently.

Horizon to horizon scanning motor.

This motor is a single phase induction machine and operates on IIOV a.c.

The motor is split phase type and hence motor rotating direction can be changed quite easily. Since the motor is of the split phase type, there are two windings of which one is the field winding which is always fixed while the terminals of the other windings are interchanged to get opposite movements.

Basically there are two parts in the circuit. One is the power supply circuit and the other is the control circuit. The control circuit involved is as shown in fig. (2.6)

The control circuit will cause two relays to be operated. One relay will be connecting the motor to the power supply while the other will be used to change the direction of the motor. The latter relay will cause an opposite connection of the stator winding in order to change the rotation direction.

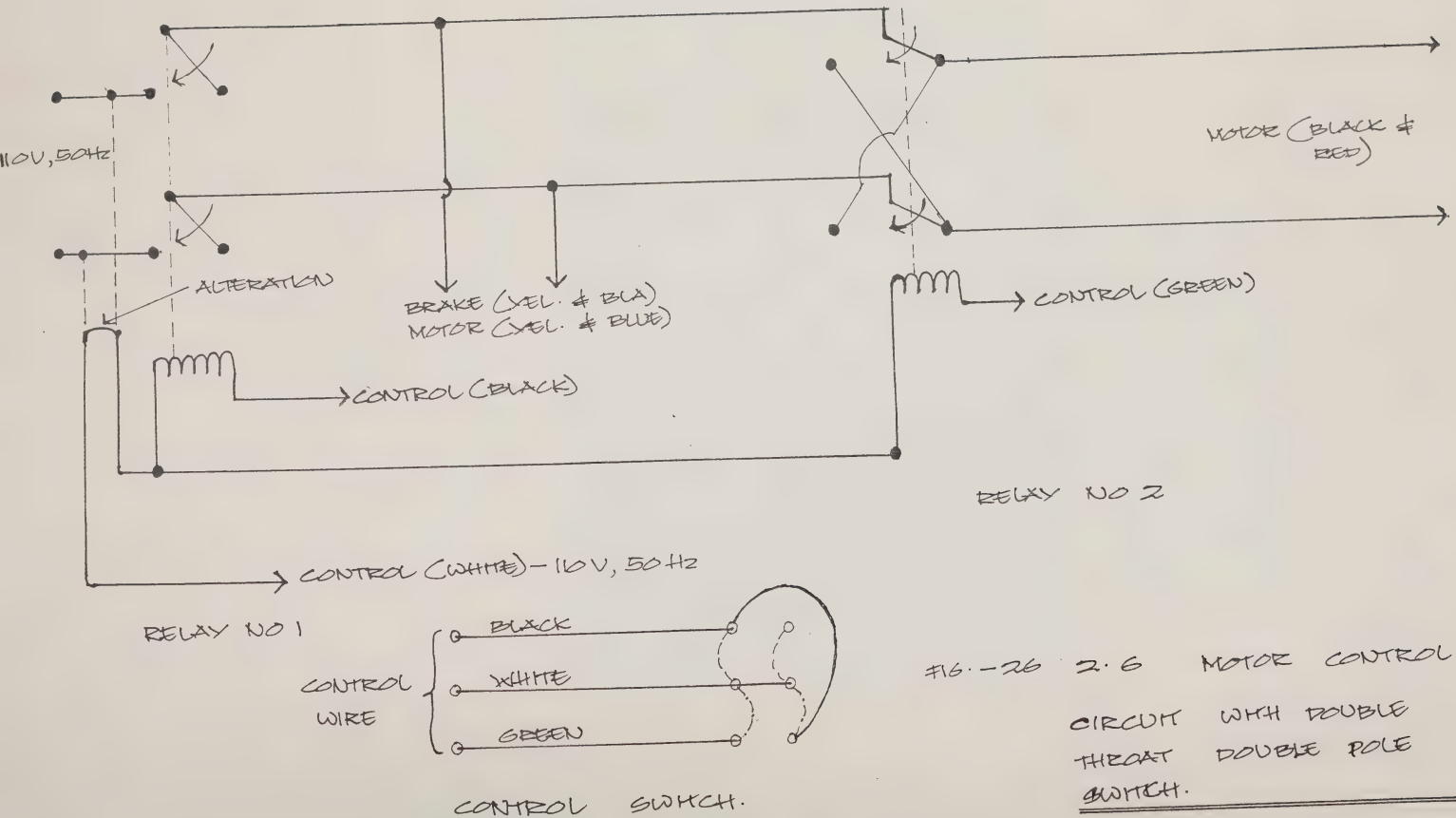


FIG.-26 2.6 MOTOR CONTROL CIRCUIT WITH DOUBLE THROAT DOUBLE POLE SWITCH.

The heavy current drawn by the motor caused a malfunction of the original control circuit. Thus we had to alter this. With the modification, the control circuit is now operated on a separate IIOV a.c. source. This has stopped the shattering of relays.

The control circuit is controlled by a double port double throat (DPDT) switch. The connections are as shown in the fig. (2.7).Under one condition this switch will cause a single relay to operate while under the second condition the switch will cause both relays to operate. The third condition will cause both relays not to operate and hence under this condition the antenna will be stationary.

The motor has a magnetic brake. When the power supply is switched 'ON', the motor brake releases and the antenna is allowed to rotate.When the power supply is 'OFF', the motor spindle is unmovable so that the antenna is stationary.

The motor incorporates a gear system which converts speed to torque sufficient to move the antenna.

Actuator Jack.

This jack causes the antenna to move in a perpendicular direction to the equitorial plane. This movement under normal condition should be nill. The use of the jack becomes necessary due to various reasons, to obtain a better picture. One such is the figure of eight movement of the satellite.

FIG (27)

ACTUATOR JACK

This hydraulic actuator can be driven up or down. The hydraulic pressure is derived from a motor operated on IIOV a.c.

The actuator jack should be automatically controllable. Then we will be able to control the jack for each and every satellite. This will also be very useful for tracking of satellites which have movements of the nature of figure of eight (this will be discussed later) and thus causes the signal level variation with a period of 24 hours in a stationary antenna.

Polar-rotor.

The polar-rotor enables us to receive LHCP and RHCP waves equally well.

The LNA probe is rotated by 90° using this polar-rotor. We have the option of rotating the probe smoothly over the range or making the probe rotate 90° at once.

The optimal position of the probe is determined by observing the received video signal.

I2V d.c. is used to power the polar-rotor.

Limit Switch

The primary function of these switches are to limit the movement of the antenna within a safety region in the horizon to horizon scan.

The switch that was avaibalbe to us was made for d.c. operation. However, we have modified it such that it now operates on a.c.

The switch consists of two mercury (Hg) bulbs which control the limits at the two ends. These bulbs are in series with the power line to the motor and hence provides ultimate safety. If the antenna is driven beyond any of the limits, power to the motor will be cut off.

West end limit and east end limit can be pre determined by the operator using the nobs on the limit switch casing.

Transformer.

The single phase transformer has been manufactured by Acme Electric Co., New York. This has a primary rated voltage of 230V while the secondary rated voltage is IIOV.

It is very important to install this transformer inside (i.e. where the air is clean and away from areas that have excess quantities of dust, corrosive fumes, bear or other adverse atmospheric conditions) and in an upright position.

It is necessary to install this transformer in an upright position or else, proper cooling will not be possible and the transformer will over heat and burn out in a relatively short length of time.

This dry type of transformer must be protected by lightning arrestors or other suitable equipment from out side lines which may cause lightning and switching surges to be transmitted to the transformer.

The enclosure of the transformer should be grounded to a water pipe or similar type of effective common ground.

The transformer should not be loaded above the rating as over loads will result in a reduced life expectancy.

Practically no maintenance is required on a dry type of transformer. In the event of a dry type transformer accidently being wet, it must be cleaned dried out before being connected to the power lines.

CHAPTER III

A STUDY ON RECEPTION CONDITIONS

CHAPTER III

A STUDY ON RECEPTION CONDITIONS.

3.I. Antenna Alignment.

As previously mentioned, it was an aim of our project to receive from many satellites as possible.

At the begining of the project we were able to receive only from one satellite. This was found to be due to the non-alignment of the antenna.The antenna when correctly aligned should have it's plane of scanning parallel to the equitorial plane.

These two planes intersect at a line. However, the point of intersection of this line and the line along which a geostationary satellite was travelling was the point at which the antenna was directed. This is how we managed to receive signals from only one satellite even when the antenna was not aligned accurately.

Therefore, the antenna had to be re-aligned so that it would rotate in the equitorial plane.

Towards mid I984m Messrs. Samuel and Sons., started work on it. After so many weeks of hard labour the antenna was fixed in it's correct position.

Soon after the re-installation work by Samuel and Sons., we were able to receive about three satellites.

However, at the moment we are not in a position to receive from any satellite as we feel, both the LNA and the receiver are faulty.

The detection of the fault of the LNA has become difficult as we are unable to find a 4 GHz signal generator.

In order to locate the fault of the receiver we have to analyse each section throughly. This too has become very difficult since we have not been supplied with any circuit diagrams of it.

Another major problem is encountered in the reception of signals when the horizon to horizon motor is actuated. The motor draws high current at the start and thus causes the supply voltage to be dropped.

This problem could be overcome by replacing the existing motor with a battery operated motor. This is essential not only because of the above problem but also to achieve a better resolution in the movement of the antenna.

Some satellites use half bandwidth of a transponder for TV transmission while others use the full. However, this does not cause much of a problem as our receiver has the possibility of selecting either.

3.2. Improvement of picture quality.

TV programmes we received cannot be labled as 'poor' at a preliminary stage as this. However, except one, other received signals were quite noisy. In order to obtain a picture with better quality we can use two methods: one is to reduce the quantity of noise while the other is to increase the signal level.

3.2.I. Noise Reduction

In trying to minimize noise effects at the antenna, we should try to suppress the antenna side lobes and increase the main lobe to side lobe ratio. Otherwise, due to antenna side lobes the antenna will be receiving signals from other satellites and thus degrade the receiving picture quality.

As the antenna is situated well above the ground level, antenna is immune to ground effects such as reflections and obstructions such as trees buildings etc. This also helps us to get a better picture.

Transmit cables add thermal noise to the system and we must try to minimize the length of cables used, inorder to reduce noise effects from these.

It would be a rewarding process to find out ways and means of further reducing the overall system noise figure.

Considering the LNA system, we see that the solid state devices are improving in performance daily while it's cost is comming down.

Thus in hte near future we may be able to replace the existing LNA with a superior one without incurring a great expence.

There is another way in which we could achieve an improvement in the system gain. This is by narrowing the bandwidth. It is a known fact that when the system is broadband the gain drops and vice versa. Improvement of gain by this method is only possible if there are consistant programmes in a particular range of frequencies, so that narrowing the bandwidth will not limit the entertainment.

For example, Intelsat always transmits TV signals in the range 4157 - 4198 MHz. If there are other satellites that transmit signals in this range it is possible for us to concentrate in this region of frequencies and design a narrowband system.

It may also be possible to design the receiver circuit in a better way to suit local conditions from which we would be able to achieve a better gain and thus improve the system gain.

3.2.2. Signal improvement.

This is the other factor in achieving a better picture quality.

The cause for a poor signal level can be attributed to many facts. One of them is that we are in the global zone of many satellites. The power density of the global zone is comparatively lower than other zones. Since there does not seem to be any spot beams in our region, we will have to tolerate this level of power density i.e. it is not realistic to design our receivers to suit other zones such as spot beams, hemi spheric zones etc.

A solution to improvement of system gain may be sought by considering the antenna, LNA and the receiver.

The system gain could be increased if we improve the efficiency of the antenna system. The efficiency of the antenna at present is about 66% according to the specifications and this is relatively high. Therefore, this improvement may be achieved with great difficulty and by incurring a high cost.

If the antenna diameter is increased again we can obtain a better antenna gain. However, we must not forget the fact that this system should be afforded by an individual and hence a compromise between the antenna gain and cost is much needed.

Thus we may not be able to increase the antenna gain at this stage.

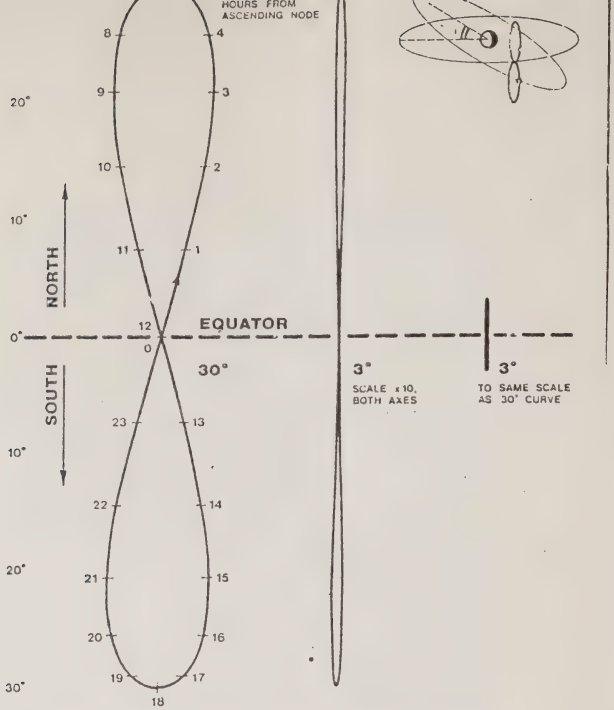
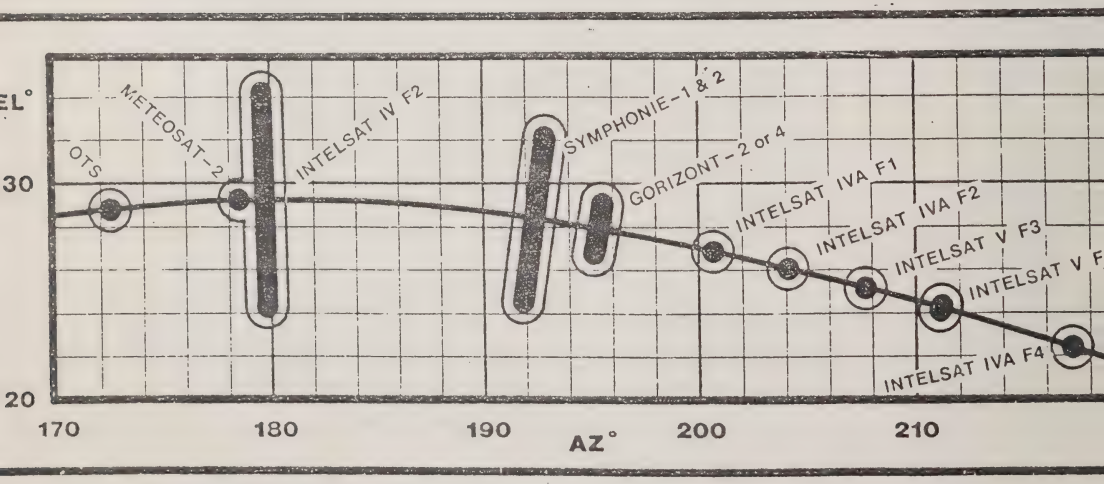


FIGURE ONE / SHAPE OF FIGURE '8' CURVE



URE TWO / Az-El PLOT OF PART OF SKY, SHOWING INCLINED ORBIT BIRDS

3.2.3. Improvement with tracking

There is another major problem caused by inclined orbital satellites. As shown in the fig. (3.I.) some satellites do not move exactly on the equitorial plane; instead they move in an inclined plane.

Under such conditions we observe a severe variation in the signal strength received. This variation is caused daily as the period of satellites is 24 hours.

The cause for this inclination is to economise satellite station keeping manoeuvers.

Depending on the inclination angle the size of figure of eight curve varies. If the orbit is truly circular, and the inclination is low, the path traced out by the satellite is alone, slim figure of 8 shape relative to the mean location or to the mean sub-satellite point on the rotating path.

However many communication satellites do not have high inclination angles, demanding automatic tracking. They are within the range of the major lobe of the antenna and receive well under any circumstance and time.

The satellites that have a higher inclination angle are satellites such as Gorizont and Intelsat. These satellites have to be tracked in both axes for better performance. This tracking has to be done throughout the day.

To make such tracking automatic, there are two fundermental approaches.

First, we could programme a steering computer with the orbital elements and perturbing forces, so that the antenna always would know where the satellite should be. Any station manoeuvres would require input of the new data to keep the computer model current.

The second approach is to give the system a form of automatic tracking, so that once locked on to the satellite it follows it automatically.

Ideally this method requires a beacon though the down link can be used if it operates continously. If not, then either an inhibit and requisition routine must be built in, or a hybrid of the prediction and tracking modes be employed.

Padukka Satellite Earth Station which receives only from INTELSAT V satellite throughout the day has an automatic tracking system using a beacon.

One of the above systems can be used in this system as a future development. Presently, this tracking is done manually by moving the actuator jack and the main motor.

3.3. Improvement of audio

There is a major problem in receiving audio in most of the TV signals. This causes a lot of problems in searching for satellites because audio is the part that is easily detectable.

Even in the few satellites that were received by us, we felt that the audio either did not match the picture received or it was inaudible.

This suppression of audio is done purposely in order to dissuade people from using TVRO systems.

There are three basic ways by which audio can be hidden.

(I) To shift the audio carrier to a position where it is not easy or possible to demodulate.

(2) The sound comes in another transponder. This problem could be overcome if audio is sent in a single carrier (if FDM system is not used).
Then the output from the LNA can be divided into two and one will be sent for picture detection while the other will be sent to a SCPC demodulator. However, if sound comes within a FDM signal demodulation is quite tedious.

(3) The sound is sent in the sync interval using some form of PCM system. This PCM may be demodulated and it should be possible to design and implement a PCM decoder to be used to detect sound. This method of suppression is mostly used in Russian satellites.

CHAPTER IV

ANTENNA DIRECTING SYSTEM

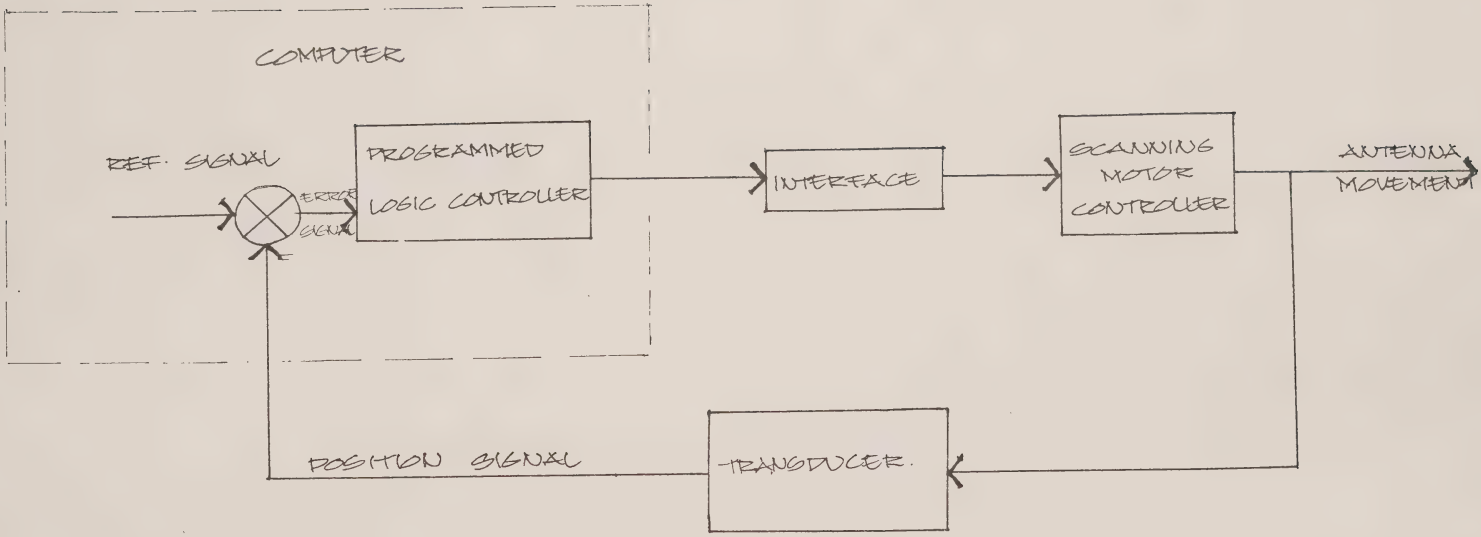


FIG. 4.1 BLOCK DIAGRAM OF AUTOMATIC ANTENNA DIRECTING SYSTEM.

CHAPTER IV

ANTENNA DIRECTING SYSTEM

4.I. Introduction.

TVRO systems are designed to receive from many satellites. Therefore, the antenna should be easily moveable from horizon to horizon allowing to access satellites which are geostationary satellites. To access a satellite the antenna should be directed towards it. The antenna, at first was made to rotate manually.

However, as there are many satellites visible, manual tracking proved to be both tedious and time consuming. More over, we are operating the TVRO system from a place where it is difficult to see the antenna pointing so it was necessary for us to go for a automatic antenna directing system.

The previous system of manual directing can also be used in parallel with the present automatic antenna directing system.

In order to implement this antenna directing system we used a micro computer. This micro computer is used as the antenna movement controller, replacing the manual controller. However to use the micro-computer as the antenna controller we must have an interface between them. In order to control the antenna we also must set up a logical sequence that will be followed by the computer. Also the computer must be up dated with the most recent antenna position data in controlling the antenna movement. Above three factors can be categorized under two sections viz. Hardware and software.

FIG (4.2)

THE TRANSDUCER

The block diagram of the automatic antenna directing system is shown in the fig. (4.I.). The reference signal, error signal and the preprogrammed logic controller are explained under software section while the transducer and the interface are described under hardware section.

4.2. Hardware

4.2.I. The transducer

This gives a voltage signal corresponding to the antenna position. Rotation of horizon to horizon motor spindle causes the tapping of a potentio meter to vary and gives rise to such a signal.

The transducer we used as mentioned, is a hali-pot. Since the hali-pot is a potentiometer using circular movement and also as it turns IO turns before reaching the full resistance, use of this kind of potentiometer was the easiest and accurate transducer we could think of.

However, as the motor spindle rotates more than IO turns in the horizon to horizon scan we had to use a scaling method to couple the transducer to the motor shaft.

We preferred a pair of pulleys to a gear wheel system. This was primarily due to the facts of difficulties in obtaining back-lash-less gear wheels.

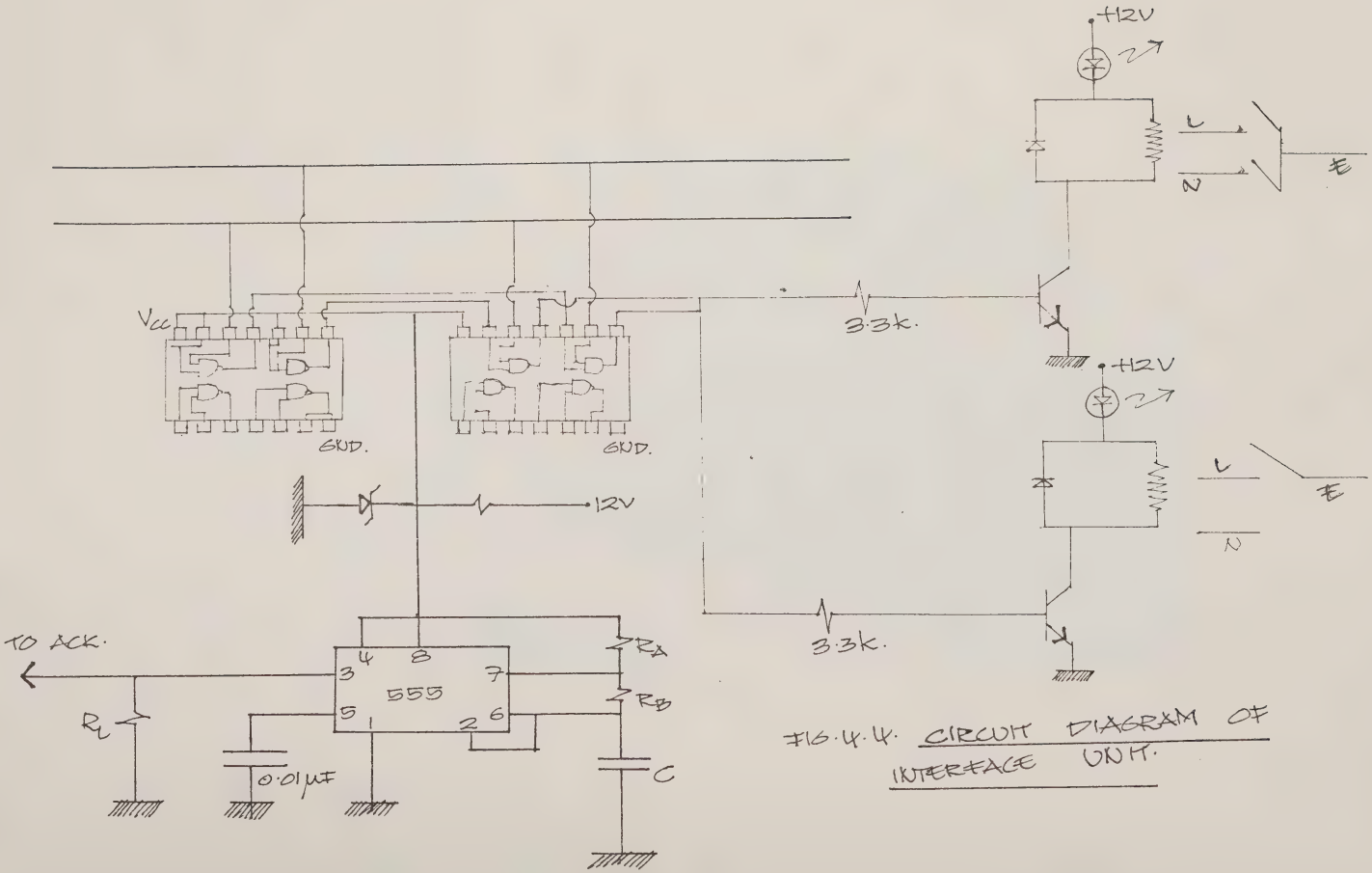


FIG. 4.4. CIRCUIT DIAGRAM OF INTERFACE UNIT.

We have coupled the pulleys by a rubber belt. This however cannot be claimed as a perfect method as it has it's imperfections; viz. the belt gets stretched, slipped and backlashed.

The hali-pot is fed with a d.c. voltage of 5.6V and hence the position the signal lies in the range 0 - 5.6 V. Since the computer can handle signals only up to I.8V the position signal is scaled down to suit the above mentioned value. This scalling is done using a high precision resistor devider network.

The divider is of high input impedence so that it would not affect the transducer. The cause to use a higher voltage operating the transducer is to reduce the noise effects. When we use a divider the noise effects also get reduced.

The analog input port pin configuration of the BBC micro computer is shown in the fig. (4.4). As the maximum signal the port can handle is I.8 V this port is protected by hazardous voltages by the use of three diodes coupled in series as shown.

4.2.2. Interface

This is the device that matches computer to the antenna. In otherwords computer and the antenna do not have a common media of communication and hence controlling signals of the computor have to be interpreted in terms of the control signals of the antenna.

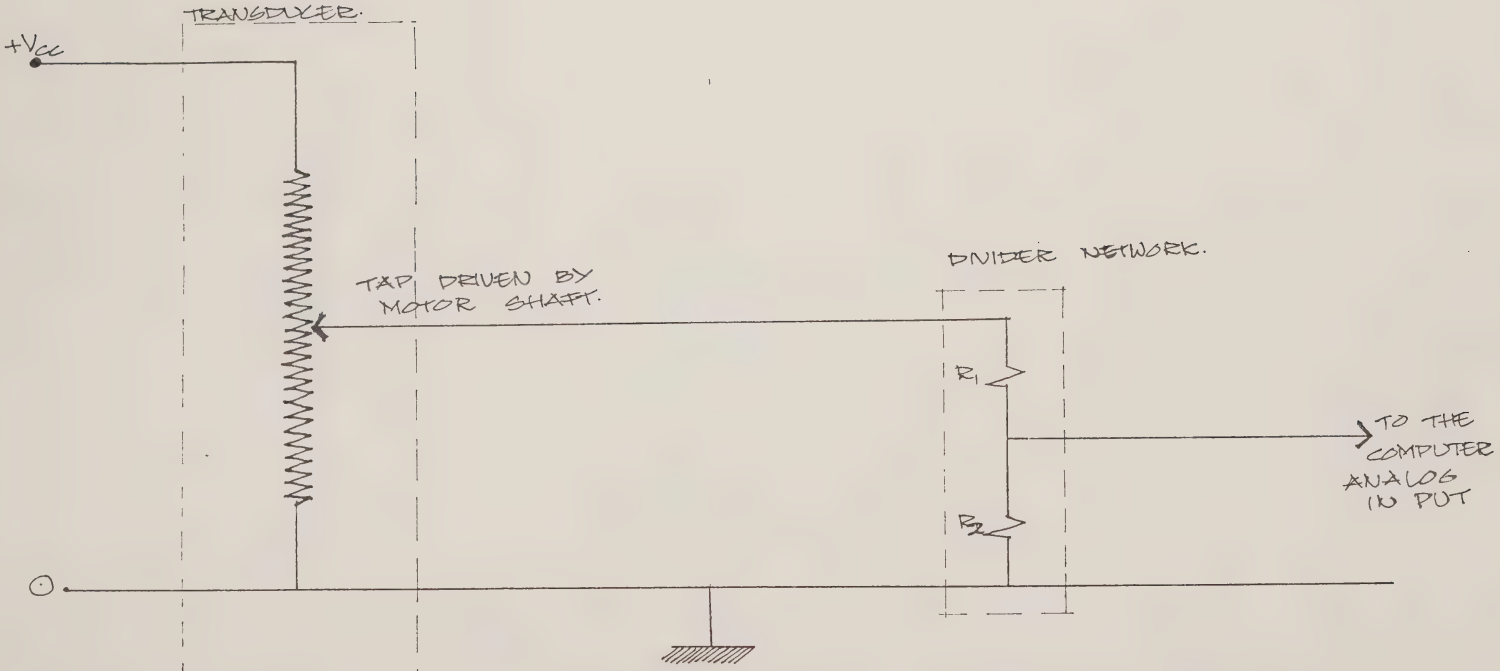


FIG. 4.3 CIRCUIT DIAGRAM OF TRANSDUCER.

The control signals of the computer are put out from it's output ports as a binary word (a byte). There are two binary outputs in the micro computer viz. USER and PRINTER.

Generally for interfacing problems other than that of a printer are encountered by the USER port. However we had a problem in obtaining a suitable connector to suit the USER port. Since the PRINTER port connector was available we decided to use the printer port.

As we will not be needing to take any printed information out from the computer, the use of the PRINTER port for our purpose will not limit the versatality of the micro computer. More over as we are not using the micro computer to do any computations, by not using the USER port our design has not been degraded.

However the use of the PRINTER port demanded us to simulate conditions of a printer at the port. For this we had to acknowledge the computer after each data sent out. Otherwise the computer does not send the next byte of data out.

We first thought of using the strobe pulse sent by the computer along with each data to be used to generate this acknowledgement pulse.However we believed the use of this method will not improve our design much and hence we used a pulse train to acknowledge. This pulse train is obtained from a astable multivibrator circuit using a 555 timer circuit.

The rate at which the computer sends out the data depends on the frequency of the pulse train.

The duty cycle of the pulse also was a trivial matter and we kept it closer to 50%. As we were operating TTL devices the output of the pulse was kept compatible with them (approx. 5V). This was obtained by supplying the correct V_{ce} value to the timer circuit.

There are three distinct horizon to horizon scan motor movements viz. west movement, east movement and stop. This means that the computer has to send atleast three mesages to the antenna to make it understand what movement the computer desires.

These messages are three selected letters in this case as we are using the printer port. The printer port represents [illegible] letters in ASCII code and therefore a letter in the printer port is a byte.

When the computer is asked to move the antenna to a desired position the computer acquires the present antenna position and makes a decision i.e. to which direction the antenna should be moved. This decision is sent via the PRINTER port to the interface which controls the actual movement of the antenna.

As there are only three messages to be sent from the computer, use of two bits of the data byte would be sufficient. For the two movements we have messages with highest hamming distance (i.e. 2, OI & IO) in order to reduce the risk of being misinterpreted.

More over we have used a logic circuit to detect these signals. This circuit acts also as a buffer to the printer port (for the bits used).

The motor is made to stop when the computer outputs a message of 'OO'. For the unused word 'II' the logic circuit does not allow the antenna to move. The main purpose of this logic circuit is to provide a failsafe controlling system.

We have simulated the conditions of the manual controller in the interface. When a person desires to move the antenna to one direction he has to common three wires together. If he wants to move the antenna in the opposite direction he has to common only two terminals of the motor control circuit. Ref. fig. (2.6)

These short circuiting processes are achieved via relays. These relays are operated by transistor switches that switch 'ON' or 'OFF' depending on the signal given by the logic circuit to their bases.

When the base of the transistor is given a high (+) level such as 5V it starts conducting. For a low level such as O V, the transistor is off. Fig. (4.4) gives the circuit diagram of the interface which is self explanatory.

The relay circuit works on I2V d.c. and this was derived by half wave rectification of a.c. We have smoothened it using capacitors because we need to have a more stable 5V supply. Logic circuits (7400 and 7408 gates) and 555 timer circuits work on a 5.6V regulated supply. A supply was needed as we were mostly working with TTL devices.

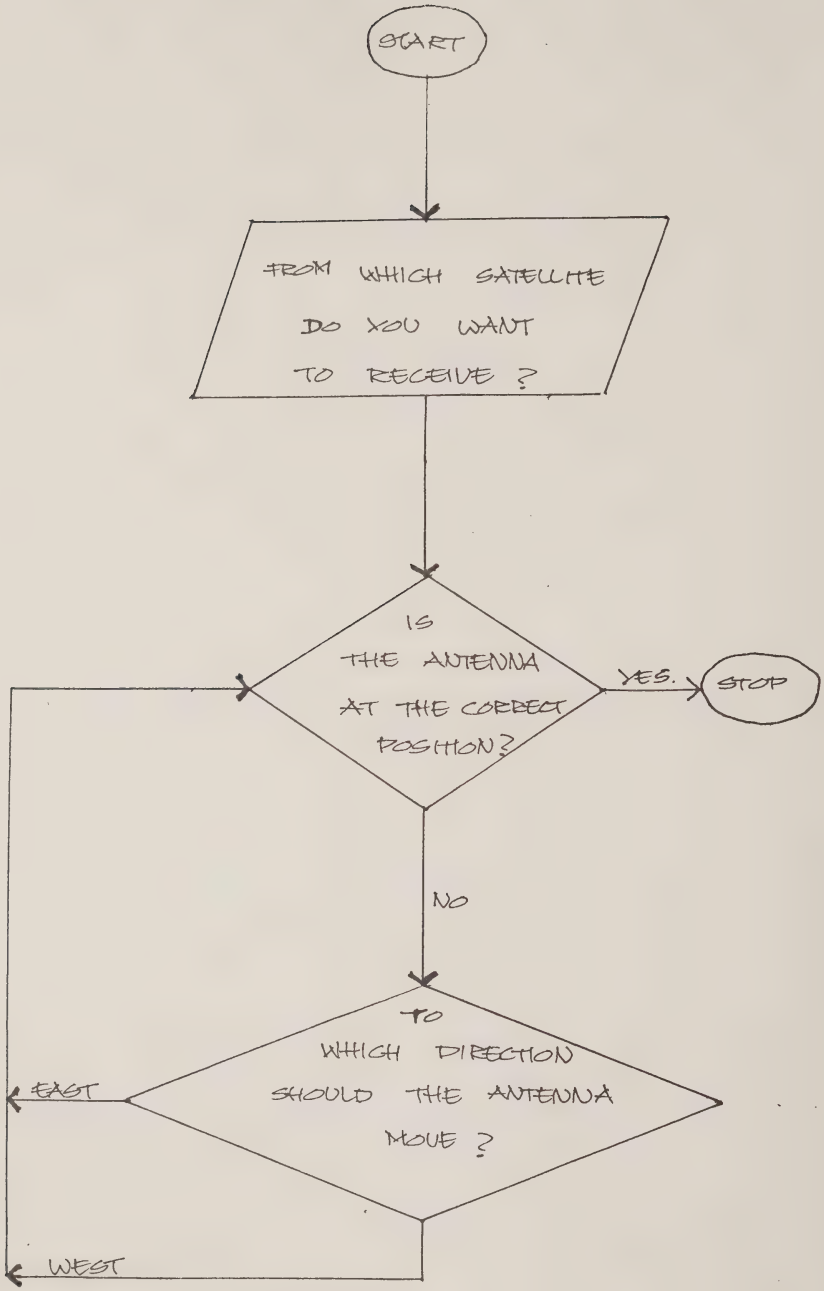


FIG. 4.5 FLOW CHART FOR SOFTWARE

The regulator circuit used is depicted in fig (4.4) and is a simple zener regulator. Smoothing and regulation of the 5.6V supply was an essential feature demanded by the transducer circuit, because it required a stable circuit.

4.3. Software

Software provides the logic of the antenna control. This is the part that replaces the thinking part of a human. The fig.(4.5.) gives the flow chart of software.

When the program is made to run, the computer will invite you to choose your favourite satellite from the menu. This menu is prepared by using computer graphics available in the BBC micro computer. The lines from 70 to 90 will create the menu on the screen.

The next step of the computer is to wait for the user to taste. Depending on the choise, the computer will decide where to look for further information on the satellite. The lines from 100 to 210 gives these facilities.

When a particular satellite is chosen, the corresponding line statement directs the computer to a jump statement. For example, for the fifth satellite, the computer is directed to the jump statement at line 610 . At this line we have stored the satellite position.

Next the computer asks for a pause to work on. Now we are arriving at the first decision box . This logic is in the inner subroutine at 22 . Here the computer up dates the antenna position data. We define two values M and N as shown in lines 230 and 240 . We have defined these values so as to avoid problems due to noise.

This sub routine provides constant checking of the antenna position with respect to the desired antenna position and sends out the ASCII code of a letter to the printer port corresponding to the desired antenna rotation direction.

The desired movement depends on the magnitudes of M and N. (i.e. $M \gtrless N$). ASCII characters used in our programme are A & B.

Before sending the character out we must disable the screen and enable the printer port. These are done by commands VDU I and VDU 2 respectively. Back again after sending the character to the port we must disable to port before going to the next step.

When the antenna has come to the desired position the ASCII charactor for P is sent to the printer port in order to stop the antenna. After stopping the antenna the subroutine returns back giving more graphics on the screen.

4.3.I. Up dating satellite positions and accessing new satellites.

When we wish to up date a position at which a satellite can be received, we must first get the corresponding analog to digital value of the transducer position. This can be called by the command X = ADVAL(I) and PRINT X.Then this value can replace the value of 'P' in the satellite sub-routine.

When we want to add a new satellite to the menu what we will have to do is to create another sub-routine for that particular satellite. In this manner we can make the computer access to any number of satellites.

CHAPTER V

LIMITATIONS

CHAPTER V

LIMITATIONS.

There are several limitations of the system we encountered during the course of this project. These will be briefly discussed in this chapter.

The most important one is that the costly equipment have been donated without any circuit diagrams or operating manuals. Ofcourse the value of the gift will be appreciated to a greater extent if these were available.

The absence of these would not have been felt so badly perhaps if there was a specific person in charge of the system and it's equipment.

At the moment, the system and it's operation is known only to those who are directly involved with it. Any person outside this circle, who is interested in the know how of the system would have to consult those who know it.

This way, the important information regarding the system would not be available correctly and freely.

The finer points like the necessary precautions and safety measures that should be observed by the user might not even reach him and could thus result in disastrous damage.

For example, there is equipment such as the receiver that has to be supplied with I20V while others like the transformer that are operated on 230V . Due to the non availability of literature regarding these, any person who's unfamiliar with the set up can unknowingly ruin the costly equipment in no time.

Even in the case of a damage, repairing or even locating the faulty area or part can be quite tedious since the circuit diagrams are not supplied along with the equipment. Trying to repair the faulty equipment, under these circumstances could even result in a worse situation i.e. the equipment may be beyond repair.

It seems as if we have already faced this situation as we feel our receiver is out of order. Since the circuit diagrams of the receiver are not available to us at present, we are unable to find out whether the receiver is working or not or if faulty, where the fault is located.

The non availability of testing equipment like frequency measuring equipment, signal generators etc is another limitation.

It is believed that the LNA is also out of order. Since we could not obtain a 4 GHz signal generator, we were unable to check whether the LNA was faulty or not.

We would have also preferred to have a frequency measuring equipment in the 4 GHz range so that we could have known the exact frequency of the received signals.

The failure of the breaking system of the antenna along with heavy rain and wind, caused the antenna to come crashing down. The result of this was a dent in the antenna surface.

As a result of this the exact shape of the antenna has changed and would thus increase the noise effects.

CHAPTER VI

CONCLUSIONS & DISCUSSION

CHAPTER VI

CONCLUSIONS & DISCUSSION

Our project "TV RECEPTION FROM SATELLITES" basically involves a TVRO system as previously mentioned. Our objectives, the procedure taken to achieve them along with the difficulties encountered in the process and finally the limitations have been explained in detail in the previous chapters.

However, there are a few points that have not been mentioned before. These are discussed in this chapter.

6.I. General

Weather Satellite.

At the preliminary stages of our project we visited the Department of Meteorology, with the intention of gaining information regarding weather satellites. We were having ideas of receiving from weather satellites using our system.

This mission turned out to be rather unsuccessful since most of the weather satellites are not geostationary and also they transmit at a different frequency band (Approx. 100 -150 MHz).

However, we gathered that there is a geostationary satellite stationed near Japan which transmits signals within our band of frequencies.

The transmit signals are facsimile and these cannot be demodulated with the equipment available to us. Thus we had to abandon the idea of receiving from a weather satellite.

Although we gave up the idea then, mainly due to lack of time, we feel that in future, it might be possible to develop a system to receive from this satellite. It may be a worthwile effort to design and implement such a system.

Legal Aspects.

As previously mentioned, we feel that the basic intention in the installation of the antenna and it's associated equipment is the first step to find out the feasibility of producing TVRO systems in this part of the world. We have also mentioned that to achieve this, we should find out the number of satellites receivable, the quality of the signal received etc.

However, in order to determine the feasibility of producing TVROs, apart from above we have to consider other aspects as well.

One of them is the legal aspect regarding the operation of such systems. In general, transmiting of TV signals, through satellite is legally bound even though reception is not.

Although this is so, if signals are received on a large scale commercial basis, there must be legal requirements that have to be dealt with.

Then the necessary authorities would have to be informed and the required permission would have to be obtained prior to the operation of such a system.

The cost factor of course should also be seen to. Since Sri Lanka is a small country and almost the whole island could be reached by a single antenna at Mt. Piduruthalagala, it might not be financially feasible to produce TVRO systems here.

In large countries like India, some villages could be ~~accessed~~ reached through TVRO systems, Then there are other places consisting of several islands where this system may be feasible.

However, a financial feasibility study of TVRO system production could be done.

Contribution towards Hi-Tech.

It seems at present the TVRO system is not very popular in this part of the world. However, this method of communication will be an asset in the future. Thus we could use this wonderful gift to improve the system and make it attractive to the public. This way we could contribute to the advancement of modern technology of developing countries.

6.2. Future work.

Tracking

The LNA and the receiver we believe are out of order at the moment and we didn't have a way of checking the fault. If a 4 GHz signal generator could be obtained it would be possible to check the LNA. As for the receiver, the circuit diagram if obtained would ease the effort.

If both the LNA and the receiver are in good condition then the system could be used to locate satellites and receive from them. Then the exact position of the satellites could obtained and this should be fed to the computer.

Once the actual positions of the satellites are located, the existing system could be further developed which would enable automatic tracking of satellites. This way we should be able to track each and every satellite receivable by our system at all times.

At this stage we could do away with the use of the computer and design and implement a dedicated system using a microprocessor. This device should then be capable of first directing the antenna to the desired satellite and then tracking it if desired.

Feedback system.

The feedback system can be improved by many ways. We may adopt either analog methods or digital methods.

Use of gear wheels with no backlash or specially manufactured belts and pulleys (i.e. transversely grooved pulleys and their complementary belts) are the analog methods. Digital methods are the use of shaft encoder or a pulse derived from the shaft.

If a greater reliability is required in the control position all 8 data bits of the printer port may be used.

Also the 'USER PORT' could be used instead of the 'PRINTER PORT '

The used 5V regulator circuit can be improved to obtain better power saving. In the circuit used the 18 Ω resistor consumes a large amount of power. The fig. (6.I) shows a circuit to achieve this improved version of the voltage reduced circuit.

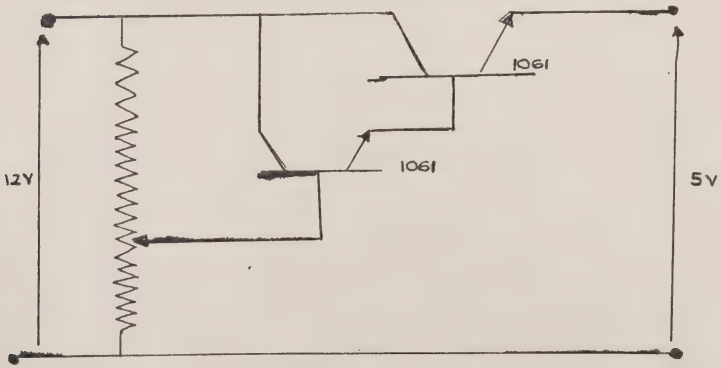


fig. (6.1)

In this circuit the open circuit current is negligible as the shunt resistance is of high value. Although power is dissipated in the transistors it is fairly low. More over, as two transistors are connected in a darlington configuration their output impedence is very small.

D.C. Motor.

In order to improve the existing system we have also mentioned in section 3.I that the motor used to rotate the antenna should be replaced by a d.c, motor.

Audio Detector Circuit.

As mentioned, a problem we faced was the inability to match the sound with the picture received. It was explained in section 3.3 how the sound carrier could be hidden.

In future perhaps it would be possible to design and implement a system which could be used to detect the sound carrier. This would be extremely useful for the future developement of the system.

APPENDIX

APPENDIX A

GEOSTATIONARY SATELLITE LOOK ANGLES.

LOCATION : COLOMBO, SRI LANKA. 6.93° NORTH
79.85° EAST.

SATELLITE NAME	NOMINAL LONGITUDE	RANGE (km)	AZIMUTH (°,RTN)	ELEVATION (°)	CLASS OF SERVICE	STATUS FOR LAUNCH DATE.	
AUSSAT -IC	160.0 °E	41560	91.2	1.1	DOM/F&B	1987	
AUSSAT - 1A	156.0 °E	41118	91.7	5.1	DOM/F&B	7.85	
CS - 2b	136.0 °E	39001	94.6	25.7	DOM/FSS	SPARE	
CS - 2a	132.0 °E	38612	95.4	30.0	DOM/FSS	OPER'L	*
PALAPA B - 3	118.0°°E	37398	98.7	45.2	DOM/FSS	9.85	
PALAPA B - 2	113.0 °E	37033	100.5	50.7	DOM/FSS	1.84	
BS - 2a & 2b	110.0 °E	36835	101.7	54.0	DOM/DBS	2.84	
PALAPA B - 1	108.0 °E	36710	102.7	56.3	DOM/FSS	OPER'L	*
EKRAN - 11 & 10	99.0 °E	36250	109.2	66.2	DOM/DBS	STAT-T	*
INSAT - IC	94.0 °E	36070	115.6	71.5	DOM/F&B	1986	
GORIZONT - 6 & 2	90.0 °E	35960	124.0	75.6	DOM/FSS	STAT-6	*
RADUGA - 12 & 10	85.0 °E	35870	143.2	79.8	DOM/FSS	STAT-3	*
PALAPA A - 1	83.0 °E	35850	155.5	81.0	DOM/FSS	OPER'L	*
PALAPA A - 2	77.0 °E	35850	202.4	81.2	DOM/FSS	OPER'L	*
INSAT - 1B	74.0 °E	35880	220.3	79.3	DOM/F&B	OPER'L	*

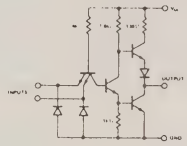
** Indicates utilisation includes TV programme relay.*

SATELLITE NAME	NOMINAL LONGITUDE	RANGE (km)	AZIMUTH (°, ETN)	ELEVATION(°)	CLASS OF SERVICE	STATUS FOR LAUNCH DATE.	
SIRIO - 1	65.0 °E	36090	245.5	70.8	DOM/FSS	EXP/OP	*
INTELSAT V F5	63.0 °E	36159	248.3	68.7	INT/FSS	PRIMARY	*
INTELSAT V F7	60.0 °E	36281	251.5	65.4	INT/FSS	MAJOR PATH	*
INTELSAT V F1	57.0 °E	36421	254.0	62.1	INT/FSS	LEASE	*
GORIZONT - 5	53.0 °E	36635	256.6	57.7	DOM/FSS	STAT-5	*
RADUGA -13 & 16	45.0 °E	37153	260.2	48.8	DOM/FSS	STAT-9	*
RADUGA - 11 & 9	35.0 °E	37947	263.1	37.9	DOM/FSS	STAT-2	*
DFS-2	28.5 °E	38536	264.5	30.9	REG/FSS	1987	
ARABSAT - 1B	26.0 °E	38775	265.0	28.2	REG/F&B	11.84	
DFS -1	23.5 °E	39021	265.4	25.5	REG/FSS	1987	
ARABSAT -1A	19.0 °E	39477	266.2	20.8	REG/F&B	10.84	
ECS-1	13.0 °E	40107	267.0	14.6	REG/FSS	OPER'L	*
ECS-2	10.0 °E	40430	267.5	11.5	REG/FSS	5.84	
ECS - 3	7.0 °E	40756	267.9	8.4	REG/FSS	8.85	
OTS	5.0 °E	40975	268.1	6.4	REG/FSS	EXP/OP	
TELE-X	5.0 °E	40975	268.1	6.4	DOM/DBS	6.86	
TELECOM-1C	4.0 °E	41085	268.3	5.4	REG/FSS	1985	
INTELSAT IV F8	1.0 °W	41636	268.9	0.4	INT/FSS	SPARE	*

APPENDIX B : Software programe for the antenna directing system.

```
[illegible]
CLS:PROCcent("Let Me Work For You
[illegible]
CLS:PROCcent("NOW I am Receiving
[illegible]
GOTO 900


      [illegible]
      [illegible]("NOW I am Receiving Fr
      [illegible]("PALAPA",1,14,1)
      [illegible]
      [illegible]

    [illegible]


GOTO 900
[illegible]
      [illegible] "Let Me Work For You",1,12,1)

      [illegible]("NOW I am Receiving From",7,12,1)
      [illegible]("[illegible]",1,14,1)
      [illegible]
      PROCcent("Go to pre school and LEARN TO [illegible]",1,12,1)
      [illegible] TO [illegible]:NEXT:
      [illegible]
      [illegible]
      [illegible]("INSAT",1,14,1)
[illegible]
PROCtab(7,20):"PRESS SPACE BAR TO SET THE [illegible]"
[illegible]
```

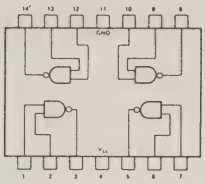
(each gate)



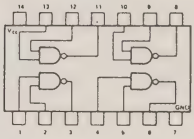
NOTE: Component values shown are nominal.

PIN CONFIGURATIONS

W PACKAGE



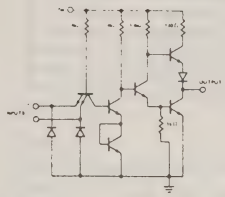
A,F PACKAGE



		MIN	NOM	MAX	UNIT
Supply Voltage V_{CC}:	S5400 Circuits	4.5	5	5.5	V
	N7400 Circuits	4.75	5	5.25	V
Normalized Fan-Out from each Output, N				10	
Operating Free-Air Temperature Range, T_A:	S5400 Circuits	-55	25	125	°C
	N7400 Circuits	0	25	70	°C

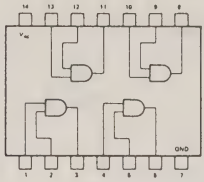
(over recommended operating free-air temperature range unless otherwise noted)

PARAMETER		TEST CONDITIONS*			MIN	TYP**	MAX	UNIT
$V_{in(1)}$	Logical 1 input voltage required at both input terminals to ensure logical 0 level at output	V_{CC} = MIN			2			V
$V_{in(0)}$	Logical 0 input voltage required at either input terminal to ensure logical 1 level at output	V_{CC} = MIN					0.8	V
$V_{out(1)}$	Logical 1 output voltage	V_{CC} = MIN, I_{load} = −400μA	V_{in} = 0.8V,		2.4	3.3		V
$V_{out(0)}$	Logical 0 output voltage	V_{CC} = MIN, I_{sink} = 16mA	V_{in} = 2V,			0.22	0.4	V
$I_{in(0)}$	Logical 0 level input current (each input)	V_{CC} = MAX,	V_{in} = 0.4V				−1.6	mA
$I_{in(1)}$	Logical 1 level input current (each input)	V_{CC} = MAX,	V_{in} = 2.4V				40	μA
		V_{CC} = MAX,	V_{in} = 5.5V				1	mA
I_{OS}	Short circuit output current†	V_{CC} = MAX		S5400	−20		−55	mA
				N7400	−18		−55	



NOTE: Component values shown are nominal.

W PACKAGE



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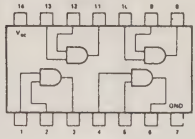


		MIN	NOM	MAX	UNIT
Supply Voltage V_{CC}:	S5408 Circuits	4.5	5	5.5	V
	N7408 Circuits	4.75	5	5.25	V
Normalized Fan-Out from Output, N				10	
Operating Free-Air Temperature Range, T_A:	S5408 Circuits	-55	25	125	°C
	N7408 Circuits	0	25	70	°C

(over recommended operating free-air temperature range unless otherwise noted)

PARAMETER		TEST CONDITIONS*			MIN	TYP**	MAX	UNIT
$V_{in(1)}$	Logical 1 input voltage required at both input terminals to ensure logical 1 level at output	V_{CC} = MIN			2			V
$V_{in(0)}$	Logical 0 input voltage required at either input terminal to ensure logical 0 level at output	V_{CC} = MIN					0.8	V
$V_{out(1)}$	Logical 1 output voltage	V_{CC} = MIN, I_{load} = -800μA	V_{in} = 2.0V,		2.4	3.3		V
$V_{out(0)}$	Logical 0 output voltage	V_{CC} = MIN, I_{sink} = 16mA	V_{in} = 0.8V,			0.22	0.4	V
$I_{in(0)}$	Logical 0 level input current (each input)	V_{CC} = MAX	V_{in} = 0.4V				−1.6	mA
$I_{in(1)}$	Logical 1 level input current (each input)	V_{CC} = MAX,	V_{in} = 2.4V				40	μA
		V_{CC} = MAX,	V_{in} = 5.5V				1	mA
I_{OS}	Short circuit output current†	V_{CC} = MAX		S5408	−20		−55	mA
				N7408	−18		−55	

DESCRIPTION

NE/SE 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA or drive TTL circuits.

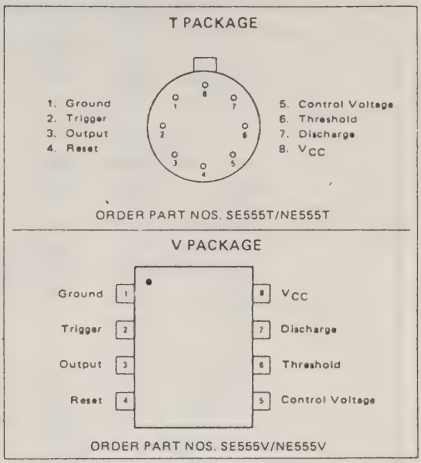
FEATURES

- TIMING FROM MICROSECONDS THROUGH HOURS
- OPERATES IN BOTH ASTABLE AND MONOSTABLE MODES
- ADJUSTABLE DUTY CYCLE
- HIGH CURRENT OUTPUT CAN SOURCE OR SINK 200mA
- OUTPUT CAN DRIVE TTL
- TEMPERATURE STABILITY OF 0.005% PER °C
- NORMALLY ON AND NORMALLY OFF OUTPUT

APPLICATIONS

- PRECISION TIMING
- PULSE GENERATION
- SEQUENTIAL TIMING
- TIME DELAY GENERATION
- PULSE WIDTH MODULATION
- PULSE POSITION MODULATION
- MISSING PULSE DETECTOR

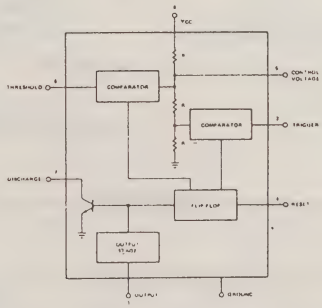
PIN CONFIGURATIONS (Top View)



ABSOLUTE MAXIMUM RATINGS

Supply Voltage	+18V
Power Dissipation	600 mW
Operating Temperature Range	
NE555	0°C to +70°C
SE555	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60 seconds)	+300°C

BLOCK DIAGRAM



SILICON N-P-N PLANAR EPITAXIAL TRANSISTORS

BC107 BC108 BC109

Also available to BS9365—F112

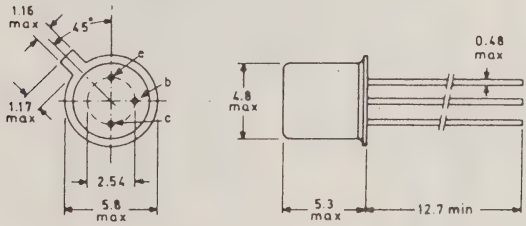
N-P-N silicon planar epitaxial transistors in TO-18 encapsulation.
The BC107 is primarily intended for use in audio driver stages and television signal processing circuits.
The BC108 is a general purpose l.f. transistor.
The BC109 is primarily intended for low noise audio input stages.

QUICK REFERENCE DATA

			BC107	BC108	BC109	
V_{CES} max.			50	30	30	V
V_{CEO} max.			45	20	20	V
I_{CM} max.			200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^oC$)			300	300	300	mW
T_j max.			175	175	175	^oC
h_{fe}	(I_C = 2mA, V_{CE} = 5V, f = 1kHz)	min.	125	125	240	
		max.	500	900	900	
f_T	(I_C = 10mA, V_{CE} = 5V, f = 35MHz)	typ.	300	300	300	MHz
N	(I_C = 200μA, V_{CE} = 5V, R_S = 2kΩ)					
	f = 30Hz to 15kHz	typ.	-	-	1.4	dB
		max.	-	-	4.0	dB
	f = 1kHz, B = 200Hz	typ.	2.0	2.0	1.2	dB
		max.	10	10	4.0	dB

OUTLINE AND DIMENSIONS

Conforms to B.S. 3934 SO-12A/SB3-6A
J.E.D.E.C. TO-18



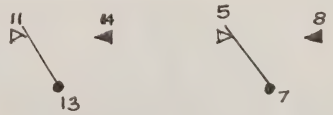
All dimensions in mm

D3648

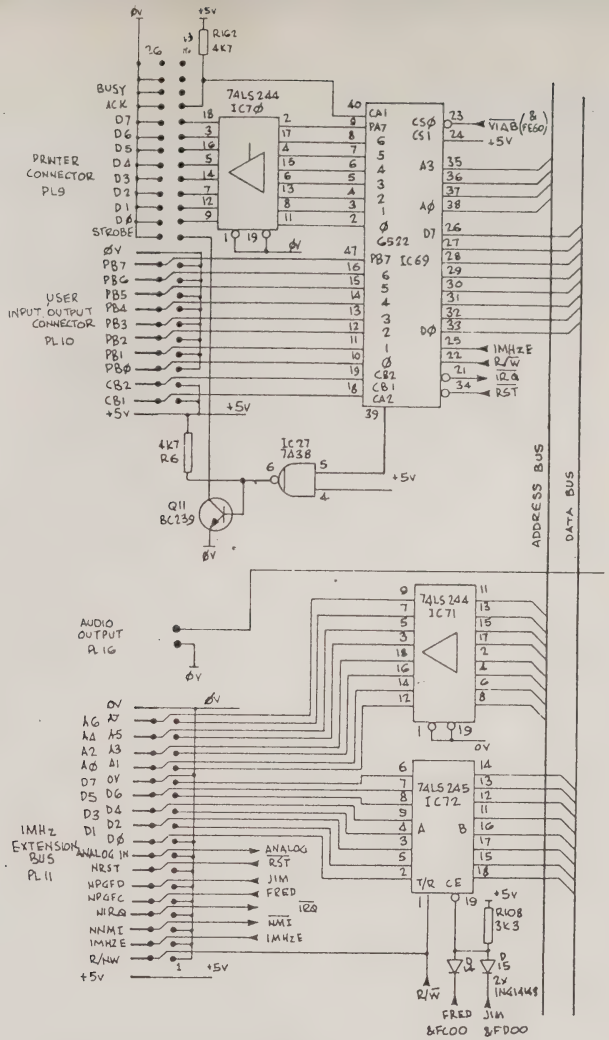
Collector connected to case
Accessories available: 56246, 56263

Mullard

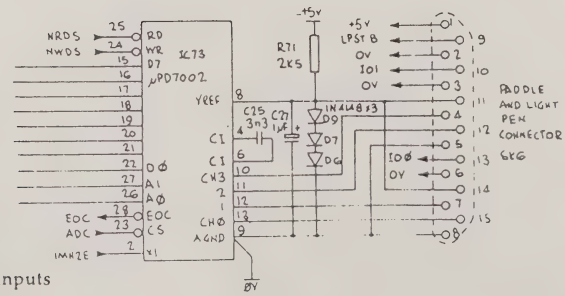
RELAY 348-920



COIL



Printer, User I/O and 1MHz Bus circuits



Analogue inputs

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1. Satellite Communications Engineering
by K. MIYA.

2. COOP's Satellite Digest.